High Energy Density Storage in Ferroelectric Polymers

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Insulating, fully-bonded polymers are dielectrics that have high electric breakdown fields. They are thus the dielectrics of choice in high power capacitors. Unfortunately, the energy densities of current capacitor polymers are quite low because of their small dielectric constants. Ferroelectric polymers from the polyvinylidene fluoride (PVDF) family have significantly larger dielectric constants, yet their energy densities are still quite low. This can be traced to early saturation of their displacement fields with the applied electric field, and to somewhat lower breakdown fields. However, an admixture of a small amount of another polymer, such as chlorotrifluoroethylene (CTFE), results in a dramatic (up to sixfold) increase in the stored energy. We postulated that this highly non-linear increase in the energy density is due to the formation of disordered nanodomains with different copolymer concentrations, which undergo first-order non-polar to polar phase transitions with an increase of the applied field. The resulting energy density profile reproduces well the experimental data, while its variation with co-polymer concentration and distribution suggest avenues for additional substantial improvements in the stored energy. While the above arguments are solely based on energetic considerations, we have recently identified a low-activation-energy pathway for the successive phase transformations. This provides further confirmation of the viability of the suggested energy storage mechanism and potentially also enables fine-tuning of the kinetics of the energy release by informed choices of suitable co-polymers.

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